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Linking the Problem and the Solution Spaces in the Case of Urbanized Information Systems: A Framework for Organizational Processes Architecture

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Abstract

Modern organizations are facing many hard problems resulting from external and internal constraints related to global business competition, fast-changing business requirements, accelerated innovation, increasing cost pressures, and regulatory compliance challenges. Thus, to grow or even survive, they have to develop solutions to these problems. The effectiveness of such solutions is related on the one hand, to the quality of both the organizational solutions developed in the problem space and the computer solutions built in the solution space and on the other hand, to the effectiveness of the alignment between business and information technology. As noted by many authors, information systems urbanization facilitates building agile information systems and high quality computer solutions. In other words, urbanization is the main device for defining consistent information system architecture in the solution space. In this paper, we propose a framework for organizational processes architecture which provides instruments for building high quality organizational solutions in the problem space, and contributes to the alignment between business and urbanized information systems through linking the problem and the solution spaces.

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Keywords: organizational process; organizational process architecture, information system urbanization; problem space; solution space; use case; service

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1. Introduction

Business models of modern organizations are impacted by their geopolitical, regulatory, legal, economic, technological, and cultural external environments. This is why they are facing many hard problems resulting from external and internal constraints related to global business competition, fast-changing business requirements, accelerated innovation, increasing cost pressures, and regulatory compliance challenges. Thus, to grow or even survive, they have to develop solutions to these problems. The effectiveness of such solutions is related on the one hand, to the quality of both the organizational solutions and the computer solutions and on the other hand, to the effectiveness of the alignment of business and information technology (IT). According to Toffolon and Dakhli [4], an organizational solution is composed of decisions, resources, activities, and roles defined in the problem space in order to overcome an organizational problem. Organizational solutions include the definition of new organizational processes or the modification of existing ones. Likewise, a computer solution refers to the architecture of the applications which computerize an organizational solution. Computer solutions are defined in the solution space [4]. As noted by many authors, information systems urbanization facilitates building agile information systems and high quality computer solutions needed by modern organizations to take into account continuous change and overcoming problems induced by external pressures [1] [2] [3] [4]. In other words, urbanization is the main device – used in the solution space - for defining consistent information system architecture that help organizations solve problems induced by slow delivery times, high maintenance costs, brittle software systems, redundant development efforts, and redundant and costly investments in multiple technologies. However, high quality computer solutions effectively contribute to value creation within organizations only if the organizational solutions they computerize are well architected, and IT and business are aligned. On the one hand, organizational solutions quality requires an organizational processes architecture which is linked to strategy and distinguishes between work completion and work management. Moreover, such architecture should be characterized by value based processes definitions and segmentations. On the other hand, there is a wide gap between the business side and the IT side. First, opportunities to use IT are not identified, authorized, prioritized, and implemented, based on importance of meeting business objectives and goals. Second, the value of IT is not understood by the business side executives who don't participate, from an enterprise-wide perspective, to decisions regarding IT direction and priorities. Third, the IT side doesn't have a clear understanding of what is important to the business. The reduction of this gap requires IT and business alignment which consists in creating and managing a business driven IT whose primary focus is defining and implementing computer solutions that meets the business organization's goals, objectives, and strategies. Failure to align IT with business results in many problems such as the inability to measure IT's contribution to value creation, and the difficulty to communicate strategy to employees and link strategy to budgets [5] [6] [7] [8]. Despite the rich literature about the IT-business alignment problem, the proposed solutions to this problem remain ambiguous concerning the operational transition from organizational solutions to computer solutions that take into account the priorities and constraints of both business and IT [5] [6] [7] [19] [20] [21] [22] [23]. We think that alignment of IT with business consists in linking the organizational processes architecture defined in the problem space and the various facets of information systems architecture defined in the solution space. In this paper, we propose a framework for organizational processes architecture which provides instruments for building high quality organizational solutions in the problem space, and contributes to the alignment between business and urbanized information systems through linking the problem and the solution spaces. Our paper is organized as follows. In section 2, we present a three-level architecture framework of organizational processes. Section 3 and section 4 are dedicated to the presentation of the "information city" framework and the global model of information system architecture which constitute the theoretical foundations of information systems urbanization. In section 5, we describe how our organizational processes architecture framework fits with the various facets of urbanized information systems architecture. We conclude our paper in section 6 by describing the contributions of our work and listing the future research directions.

2. The organizational processes architecture framework

An organizational process is defined as a flow of structured, measured, and related activities that together create value for the organization itself and for its customers, suppliers, and other partners. It is a construct for organizing work so it can be performed and managed efficiently and effectively in order to convert various inputs into valued outputs materialized by goods and services [15]. Organizational processes definition result in a specific ordering of work activities across time and place, with a beginning, an end, and clearly defined inputs and outputs. According to Davenport and Short [16], an organizational process is "*a set of logically related tasks performed to achieve a defined business outcome*". A typical high-level organizational process describes the means by which the organization creates value, regardless of the organizational actors and functional departments' contributions. An organizational process is inherently distributed. On the one hand, its activities are performed on different locations, by various organizational actors who may be supported by a heterogeneous set of computer systems. On the other hand, an organizational process typically crosses the borders of organizational departments. Hence, as key complex artifacts to represent how work is performed in organizations, organizational processes challenge modern organizations in their efforts to properly design and govern them through the definition of appropriate architecture. Organizational processes architecture may be defined as a set of models and architecture rules and principles that permit either outlining how work is done within the organization or configuring the specific tasks necessary to design organizational solutions. The definition of organizational processes architecture results in a repository of architecture rules to describe organizational processes and a repeatable reference blueprint to move from the current to the target business processes architecture. Organizational processes architecture defines the goals of tasks and describes their organizational and operational facets i.e. the actors who complete tasks, the informational resources required to complete tasks, and where and when tasks are completed. The goals and the organizational and operational facets of tasks take into account the organization's strategy which may modify or suppress existing tasks, or create new tasks. Identifying informational resources associated with tasks include the description of information flows through tasks within an organizational process or between many organizational processes.

Prior to presenting the organizational processes architecture framework proposed in this paper, we note that there are two types of complexity inherent in organizational processes: a structural complexity, and a systemic complexity. The former results in particular from the organizational processes size and is managed by breaking down processes into activities and activities into tasks. The later stems from the interactions between tasks belonging to one or more organizational processes and is managed using a systemic analysis based on abstraction levels [9]. Therefore, organizational processes architecture has two dimensions – structural and systemic – which take into account the two complexity types inherent in organizational processes. In this paper, we focus on the systemic dimension of organizational processes architecture and present a framework made up of three abstraction levels: conceptual, organized, and logical. In the remainder of this section, we present synthetically each abstraction level by identifying and defining the main concepts that characterize it, and providing a metamodel which describes the relationships between these concepts.

2.1. The conceptual level

The conceptual level of organizational architecture processes describes what is done in the organization from the business perspective regardless of the managerial and operational perspectives. It identifies the invariants of the organization's business and provides answers the question "What?" without concern for the answers to the questions "Who?", "When?", "Where?" and "How much?" "With what?" and "How?". The main concepts characterizing the conceptual level of organizational processes architecture are: organizational process, process type, activity, process domain, process family, flow, process customer, and flows connectors.

At this level, an organizational process is considered as a sequence of activities compliant with the organization strategy and triggered by a request or an event in order to contribute to value creation by producing goods and services. Organizational processes can be grouped into coherent domains subdivided into families. A family belongs to one and only one domain and an organizational process belongs to one and only one family. Organizational processes fall into five types: external communication, management of the relationships with customers and partners, business processes, decision-making processes, and support processes. An activity is a stage of an organizational process that achieves a sub-goal of this process by transforming an internal or external physical or

informational flow. A flow is an exchange between a sender and a receiver. There are three types of flows: material flows, financial flows, and informational flows. A flow can be issued either by an organizational actor or by an activity. A process customer is an individual or legal entity that receives the result of an organizational process. It may be the source of the initial request for this process. Flows connectors are constructs used to manage multiple input or output flows. Parallelism, condition, junction, timers, and synchronization are examples of flow connectors. The following metamodel (Fig.1) describes the relationships between the key concepts which characterize the conceptual level of organizational processes architecture.

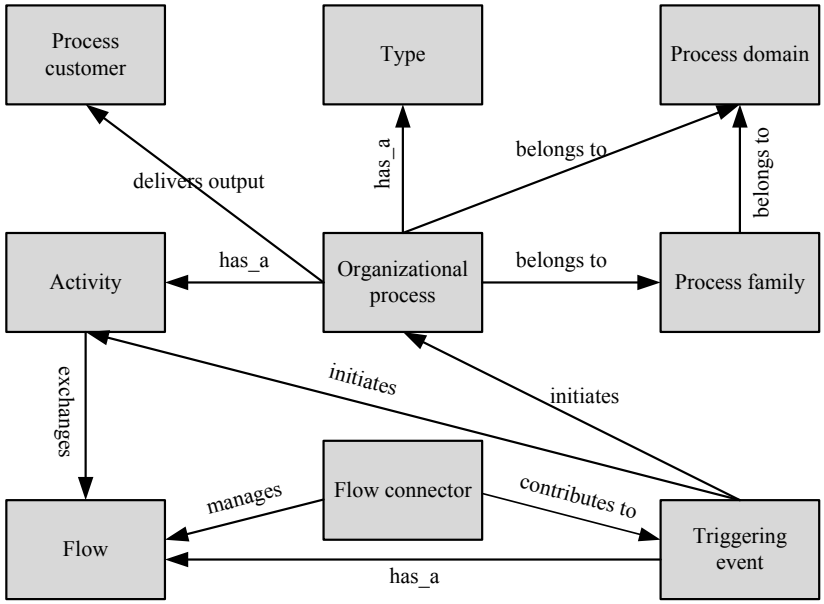

Fig. 1. The conceptual level metamodel.

2.2. The organized level

The organized level of organized architecture processes is the projection of the processes conceptual architecture on the organization's context, constraints, and priorities. Therefore, this level models organizational processes as nexuses of procedures and operations carried out by organizational actors in order to contribute to value creation. It provides answers to the questions "Who?", "When?", "Where?" and "How much?" without concern for the answers to the questions "With What?" and "How?". Besides the organizational process and activity concepts, the main concepts characterizing the organized level of organizational processes architecture are: procedure, operation, task, and organizational actor. A procedure is a variant of an activity which highlights the managerial aspects related to the performance of this activity. Therefore, a procedure doesn't result from the decomposition of an activity. Furthermore, an organizational process activity may be associated - at the organized level - to many procedures depending on the organizational choices. An operation is a stage of a procedure corresponding to the intervention of at most one organizational actor. From the organizational actor point of view, an operation is the sequence of tasks he can perform for advancing the process without switching to another actor or expecting external flows. A task is a stage of an operation. It is a significant act whose content is well targeted that the actor must perform. An organizational actor is a role played by a human resource in the implementation of organizational processes activities. A human resource may play many organizational roles and an organizational role may be played by many human resources. The following metamodel (Fig. 2) describes the relationships between the key concepts which characterize the organized level of organizational processes architecture.

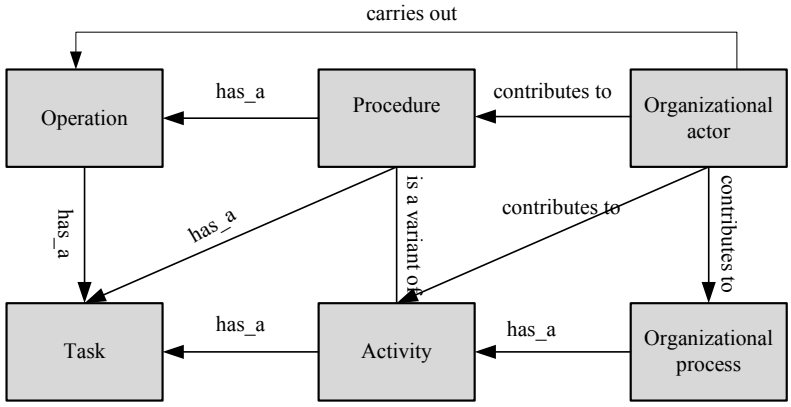

Fig. 2. The organized level metamodel.

2.3. The logical level

The logical level of organizational processes architecture describes the tools that perform the tasks of an operation. It answers the question "With What?" without regarding for the answer to the question "How?". This level links the organizational processes architecture and the information system architecture. In addition to the operation, task, and organizational actor concepts, the logical level of organizational processes architecture relies on the use case and the fully automated operation concepts. We note that there three types of tasks; manual, semi-automatic, or automatic. A semi-automatic task requires both the contribution of an organizational actor and the support of a computer system. A use case is a sequence of semi-automatic tasks of an operation carried out by the same organizational actor, and supported by one computer system. A use case doesn't include manual tasks. A semi-automatic task belongs to one and only one use case. If an organizational actor is supported by two applications while carrying an operation, this operation is decomposed in two use cases. Thus, an operation may be associated with many use cases. Nevertheless, if an operation includes many use cases, ergonomic problems may arise since the organizational actor has to switch tools while carrying out this operation. A fully automated operation is made only of automated tasks whose implementation does not require the contribution of an organizational actor. Fully automated operations are run by information's system applications. The following metamodel (Fig. 3) describes the relationships between the key concepts which characterize the logical level of organizational processes architecture.

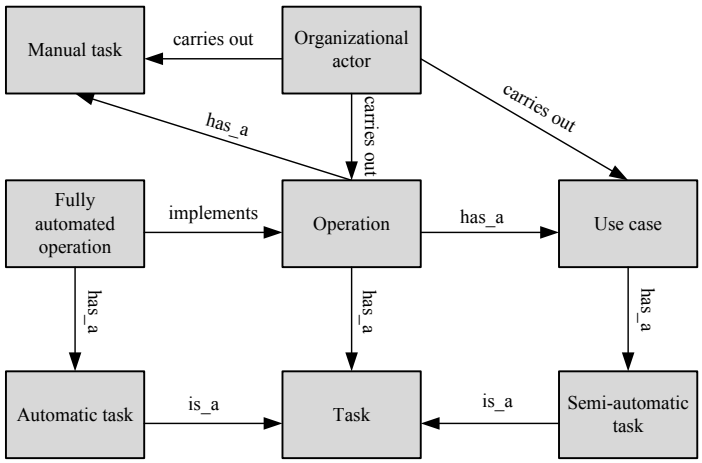

Fig. 3. The logical level metamodel.

3. The information city framework

The "information city framework" [1] generalizes the use of the "city planning" metaphor by stating that – within a modern organization – an information system may be considered as a city whose inhabitants are the applications belonging to this information system. In this city, called "the information city", the common parts include information shared by all the information system applications while the private parts are composed of software artifacts owned by each application. An application belonging to the information city behaves as a master of its own data and artifacts and as a slave regarding informational artifacts belonging to other applications of the information system. In other words, an application can use, update or suppress data and artifacts it owns but can only use a copy of informational artifacts managed by other applications.

Comparing an information system to a city extends the use of the "city landscape" beyond the analogy between software and building construction by emphasizing the problem of information system governance. On the one hand, following the example of a city, the relationships between the applications which populate the information city must be managed. This means that a set of architecture principles and rules should be specified in order to govern exchanges either between the information system applications or between such applications and the external environment including end-users and partners' information systems. On the other hand, the vast number of application assets in combination with the natural expansion of the application portfolio as well as the increasing complexity of the overall information system, drive a need for the information system governance. Therefore, the "information city" framework permits defining architecture principles and rules which help organizations prioritize, manage, and measure their information systems. The "information city" framework results in the "Information City Plan" (ICP) which, together with the global model of information systems architecture, helps organizations build urbanized information systems.

Analysis of the principles behind the organization's and information technology strategies leads to three architecture principles which help guide the development of the organization's information city plan (ICP). The first architecture principle - Determine front-office vs. back-office responsibilities – identifies the roles of the organization's front-office and back-office. The front-office is dedicated to the management of the relationships with the organization's external environment while the back-office is responsible for the development of products and services. For instance, within an insurance company the back-office manages the insurance and services commitments whatever the distribution channels. The second architecture principle - Specialize back-office and front-office regarding the organization's processes - breaks down the organization's front-office and back-office in several areas according to the typology of organizational processes into five categories. The front-office activities are grouped into two processes categories (External communication and Management of the relationships with customers and partners) while the back-office organizational processes are classified into three categories (business processes, decision-making processes, and support processes). As a result of the second architecture principle, the organization's back-office is composed of a "Business Intelligence" area, a "Support area", and at least one business area. In addition, the organization's front-office is associated with an "Inbound and Outbound flows Management area" and a "Party Relationships area". The "Inbound and Outbound flows Management area" is dedicated to the management of the informational flows exchanged by an organization and its external environment. This area describes the various technology channels used by an organization while exchanging information with external environment. The "Party Relationship area" supports the relationships linking an organization with its customers and partners whatever the communication channel.

The third architecture principle - Identify the components common to the front-office and the back office – refers to either the components that link the front-office and the back-office or the artifacts they share. Application of this principle results in identifying two areas: an "Integration area" and a "Shared information area". The first area allows exchanges of informational flows and services between the back-office and the front-office applications. The second area contains information shared by all the applications of the organization's information system as well as the applications which manage shared information. The following schema (Fig. 4) presents an example of ICP which may be used to illustrate the information city in various service-intensive organizations like banks and insurance companies [18].

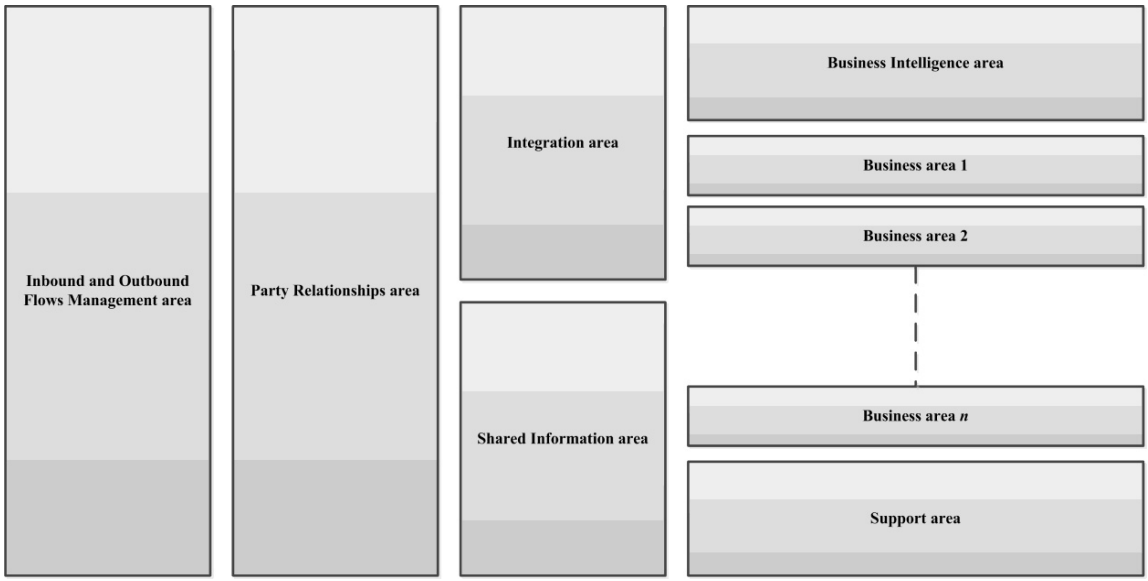

Fig. 4. The Information City Plan.

4. The Global Model of Information System Architecture

Systemic analysis of the information system architecture results in a multi-view model called "the Global Model of Information System Architecture" where each view is represented by a layer dedicated to an enterprise architecture main concern [9] [10]. This model relies on six interacting layers: the strategy layer, the business architecture layer, the functional architecture (information system architecture) layer, the applicative architecture layer, the software architecture layer, and the infrastructure layer. The strategy layer defines the organizational problems to be solved and their organizational solutions. Such problems result from the organization's external and internal constraints. External constraints may be economic, political, social, legal, or related to the evolution of the technology. Internal constraints reflect the impacts of external constraints on the organization's components: structure, people, production technology, tasks, and information technology [11] [12] [13].

The business architecture layer describes the organizational processes architecture at the conceptual, the organized, and the logical levels. At the conceptual level, an organizational process is modeled as a nexus of activities processing and exchanging information. At the organized level, the organizational processes architecture is the projection of the processes conceptual architecture on the organization's context, constraints, and priorities. Therefore, the organized level models organizational processes as nexuses of operational tasks carried out by organizational actors in order to contribute to value creation. The logical level identifies the tools – called use cases – used by the organizational actors to perform the operations tasks. The organizational processes architecture is updated according to the organizational solutions defined by the strategic layer.

The functional architecture layer describes the information system architecture as a nexus of informational entities and functions. An informational entity is a set of coherent information chunks which define a concept having a life cycle, and commonly used by the organizational actors while carrying out an organizational process. A function is an action which uses or transforms at least one informational entity. An organizational process manipulates informational entities through the use of functions. A function may be considered as an aggregation on many sub-functions. Functions may be used by many organizational processes. Such functions are called reusable functions. Informational entities manipulated by many organizational processes are called shared information. Because of the invariant and stable nature of informational entities and functions, they are independent of information technology, organization's structure, and roles played by actors. Information system architecture is defined as a model describing the organization's functions and informational entities as well as their relationships. The functional

architecture is updated by integrating the impacts of the organizational solutions defined by the strategic layer on the informational entities and functions.
The applicative architecture layer provides a map which describes the organization's applications as well as the services and informational flows they exchange. An application is composed of two parts: a software part, and a data part. The software part includes a set of interrelated software systems which computerize a coherent set of functions. The data part is made of informational entities manipulated by these functions. An application contributes to value creation by supporting - at least partly – one or more organizational processes. It may be considered as a dynamic conjunction of a set of partially computerized organizational processes activities with informational entities and functions in order to contribute to products and services production. An application provides two categories of services: service-to-user and service-to-application. A service-to-user results from an interaction between an application and an end-user who may be either a customer or an organizational actor. A service-to-application is an intermediate service provided by an application to other applications while processing information. It is a software service exposed by an application for other applications belonging to the same information system. The applicative architecture layer results from the interaction between the functional layer and the business architecture layer which supports the problem and operation spaces [4]. The applicative architecture layer delivers a first level description of a software solution as a new or enhanced application which interacts with existing and future applications.
The software architecture layer describes each software solution as a set of software components and connectors distributed according to a software architecture model (e.g. MVC,…) [14]. A software solution is either the architecture of a new application which supports, at least partly, one or more new organizational processes or the architecture of an existing application which is enhanced in order to take into account the modifications of existing organizational processes. In this paper, we define a component as an autonomous and homogeneous software artifact which implements a function in order to provide a service either to end-users or to other artifacts. A software connector is an autonomous and homogeneous software artifact which facilitates interactions between two software components. A software solution is composed of reusable and specific software components and connectors. A reusable software component implements a function used by many organizational processes. The description of the infrastructure layer is beyond the scope of this paper.

5. Linking organizational processes architecture and urbanized information system architecture

The alignment of IT with organization's business relies on the definition of links between the problem space and the solution space whereby the artifacts managed in the former are continuously supported by those managed in the later. From an urbanized architecture perspective, it follows that IT solutions defined by the information system architecture support effectively organizational solutions based on the organizational processes architecture. Therefore, analysis of the links between the problem space and the solution space consists in addressing questions regarding horizontal and vertical alignment of IT with business [5]. Horizontal alignment refers to the support provided by information system applications to organizational processes performance, integration, and management. Vertical alignment covers the capacity of information systems to adapt, within the budget and timelines constraints, to organizational solutions changes induced by the organization's strategy. In the remainder of this section, we address these two types of alignment in the case of urbanized information systems.
First, as highlighted in a previous section, the areas of information city plan (ICP) resulting from the "information city" framework are determined according to the classification of organizational processes into five categories: external communication processes, management of the relationships with customers and partners processes, business processes, decision-making processes, and support processes. As a result, the organization's back-office part of the ICP is composed of at least three areas ("Business Intelligence" area, "Support area", and at least one business area) while the organization's front-office is associated with two areas ("Inbound and Outbound flows Management area", and "Party Relationships area"). Thus, each organizational solution is computerized using a target urbanized application belonging to the ICP area determined by the type of organizational process implemented by this solution.
Second, there is a strong relationship between organizational processes and functional architecture. Indeed, according to the orthogonality principle (Fig. 6), organizational processes are carried out by organizational actors who perform tasks that manipulate informational entities through functions. Therefore; a function may be used by

several tasks of the same organizational process or by multiple organizational processes. It follows that the organizational solutions collaborate through the use of functions shared by the organizational processes they implement. In other words, reusable functions facilitate organizational solutions integration. Moreover, such functions are encapsulated by reusable services that contribute to the integration of the urbanized applications computerizing organizational solutions [17].

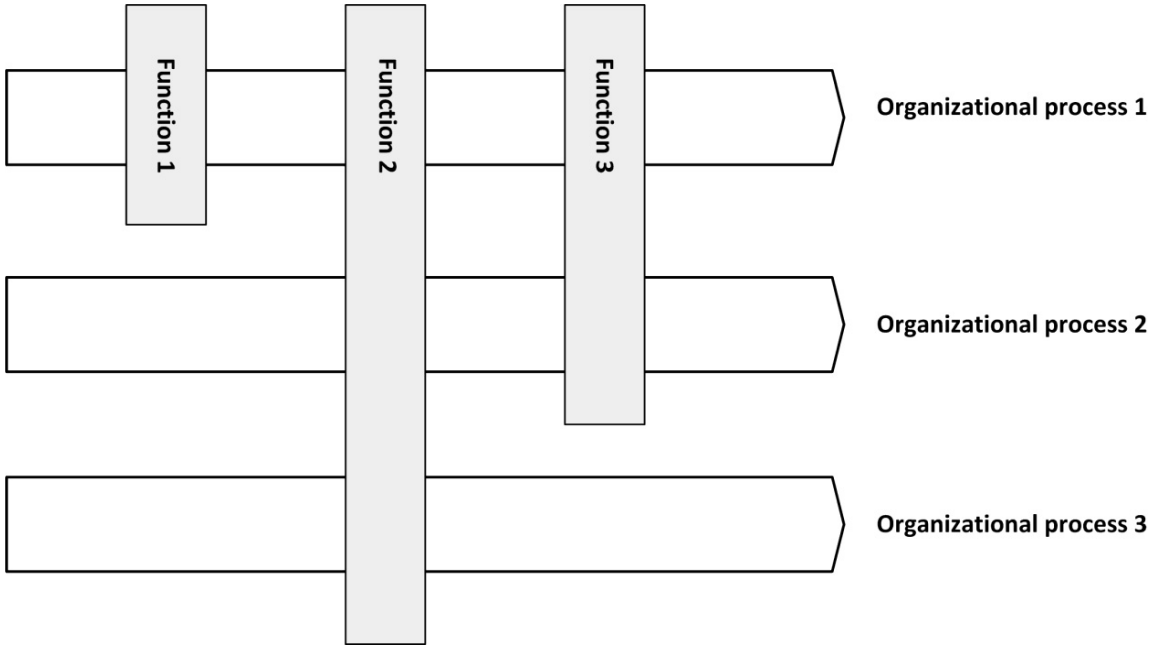

Fig. 5. Orthogonality of organizational processes and functions.

Third, the operational link between organizational processes and urbanized information system applications is based upon use cases. On the one hand, while carrying out operations organizational actors interact with urbanized information system applications through the services-to-user which implement use cases. Therefore, organizational processes are computerized either by the services-to-user implemented by urbanized information system applications or by fully automated operations run by these applications. On the other hand, use cases contribute to the alignment of IT with business by helping to structure information system applications and specify who does what with these applications. Finally, use cases are the main tools used for IT-supported organizational processes integration. Indeed, the computerization of an organizational process is based on the performance of sequences of use cases corresponding to multiple operations, performed by many organizational actors, and supported by many applications which exchange informational flows and services. Likewise, an information system application may computerize at least partly many organizational processes. It follows that the IT-supported organizational processes integration takes place at two levels: the ICP Integration area, and the Orchestration and Choreography layer of urbanized applications [18]. The ICP Integration area provides tools that carry out - at the information system global level - the orchestration and choreography of use cases associated to organizational processes operations. Moreover, within each urbanized information system application, the Orchestration and Choreography layer manages the sequence of use cases tasks supported by this application, controls the informational flows and services exchanged with other applications while running use cases or fully automated operations, and handles a context related to use cases tasks running in order to allow interruptions without data publication.

Fourth, the evolution of organization's strategy results in changes of organization's business materialized by the creation of new organizational processes or the modification of existing ones in order to build new organizational

solutions. It follows that either new activities, procedures, operations, tasks, and use cases are created or existing ones are modified. The vertical alignment of IT with organization's business is based on the propagation of changes in the organizational processes architecture, resulting from the modification of the organization's strategy, through the layers of the information system's architecture. Thus, the vertical alignment of IT with organization's business consists in computerizing new organizational solutions or taking into account the changes to existing ones within budget and timelines constraints. For example, the creation of a new organizational process impacts the information systems architecture as follows. At the functional architecture level, new functions and informational entities may be created. At the applicative architecture level, to support the new organizational process, at least one application is created and many applications may be modified depending on the number and the characteristics of the use cases associated with this organizational process. Applications created belong to an ICP area determined by the type of the new organizational process. At the software architecture level, reusable services encapsulating new reusable functions may be created. Moreover, the computerized part of the new organizational process is taken into account by the global orchestration and choreography tools belonging to the ICP Integration area.

The relationships between organizational processes architecture and urbanized information system architecture are illustrated by (Fig. 6) below.

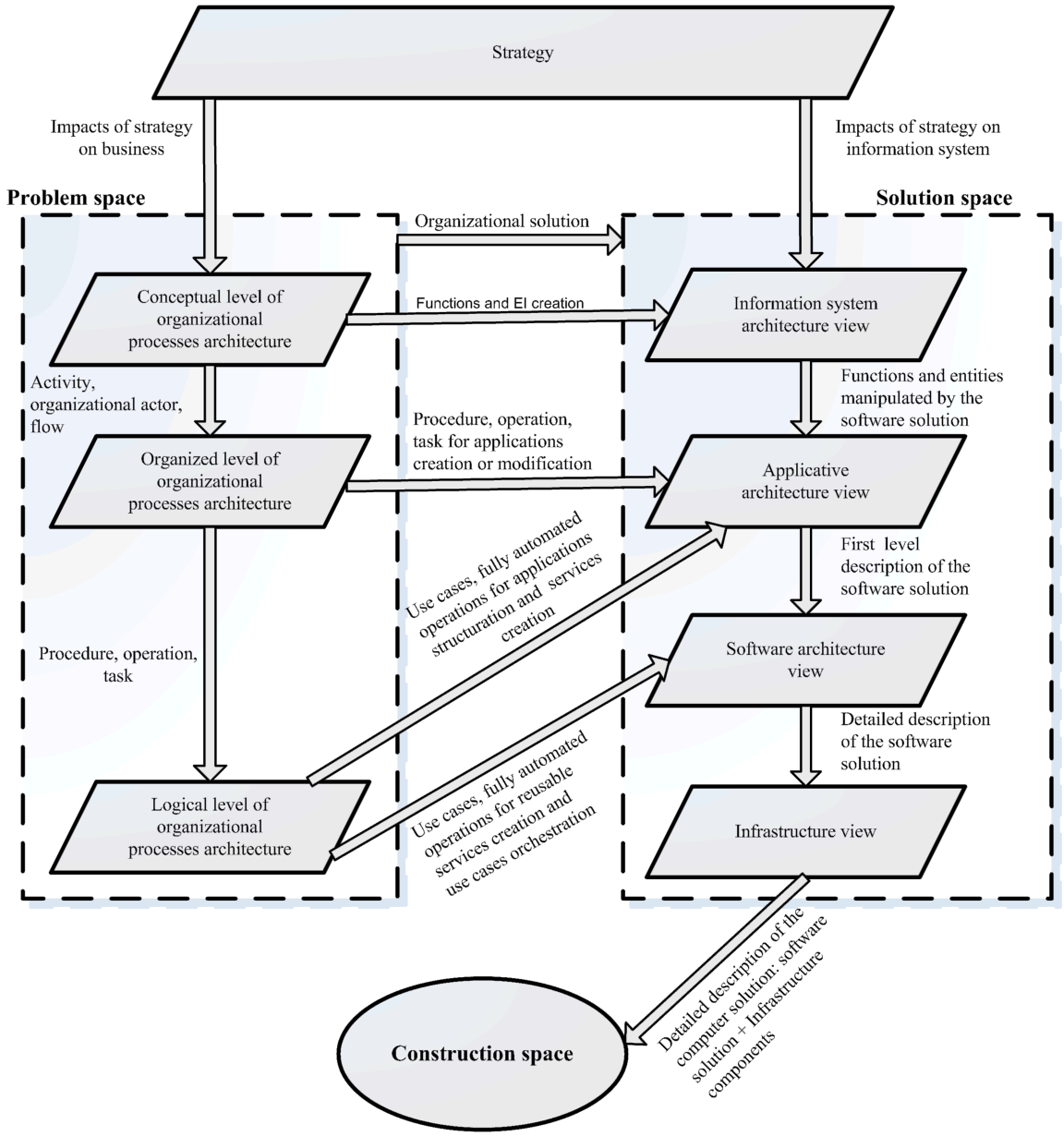

Fig. 6. Relationships between organizational processes architecture and information system architecture.

6. Conclusion and future research directions

In this paper, we have presented a framework for organizational processes architecture which provides instruments for building high quality organizational solutions in the problem space, and contributes both to the horizontal and vertical alignment between business and urbanized information systems through linking the problem and the solution spaces. The horizontal alignment refers to the support provided by information system applications to organizational processes performance, integration, and management. The vertical alignment covers the capacity

of information systems to adapt, within the budget and timelines constraints, to organizational solutions changes induced by the organization's strategy. We have validated this work in a French insurance company whose information system is to a large extent urbanized. The main applications belonging to this information system fall into three categories: proprietary monolithic systems running in a mainframe environment, web applications running in an open environment, and ERP systems that can operate in one or the other of these environments. The validation of our framework was carried out in two phases and involved company employees and external consultants. During the first phase, we have defined a business dictionary and a standard for organizational processes description. During the second phase, we created a repository for the description of organizational processes architecture. Nevertheless, we have encountered many problems both at the technical and the human levels. Technical problems include the lack of computer tools to support effectively the repository of organizational processes architecture. Human problems are related to the resistance of employees asked to describe the organizational processes due to the burden of this activity, the bad quality of the existing documentation, and the lack of incentives. This validation confirmed that the framework presented in this paper has three important contributions. First, it facilitates the management of both the structural and the systemic complexities of organizational processes. Indeed, while managing the systemic complexity through the separation of the conceptual, organized, and logical concerns related to organizational processes, the proposed framework facilitates the structural complexity management by defining the granularity of the organizational processes decomposition. Second, each abstraction level of the organizational processes architecture helps in building effective computer solutions and structuring urbanized applications through the definition of the organizational artifacts to be considered by the information system architecture views. Third, the proposed framework helps both the business and the IT sides in defining the roles associated with the use of information system, and the instruments supporting interactions between organizational actors and information system applications. However, this work should be completed by a deep analysis of the informational flows between the problem and solution spaces and the definition of a set of architectural rules that help in organizational processes decomposition and use cases definition. This is a first future research direction. Another research direction consists in continuing the validation of this work in other contexts more conducive to experimentation.

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